LABORATORY AND FIELD TESTS COMPARING FORMULATIONS OF MALATHION/RESMETHRIN WITH MALATHION FOR THE CONTROL OF ADULT MOSQUITOES

C. B. RATHBURN, JR. AND A. H. BOIKE, JR.

Florida Department of Health and Rehabilitative Services, West Florida Arthropod Research Laboratory, Panama City, FL 32401

ABSTRACT. Laboratory and field tests were conducted to determine the relative effectiveness of malathion-resmethrin mixtures and malathion only. Laboratory tests conducted with malathion susceptible species showed a slight increase in effectiveness of a 90:1 malathion-resmethrin formulation over malathion for *Culex nigripalpus*, but not with *Aedes taeniorhynchus*. With malathion resistant *Ae. taeniorhynchus*, there was no significant difference between the 100:1 malathion-resmethrin formulation and malathion.

In the field tests, both technical and dilute formulations were used in tests against *Cx. nigripalpus*, *Cx. quinquefasciatus* and *Ae. taeniorhynchus*. These tests showed no difference in mortality between any of the malathion-resmethrin formulations used and malathion, but indicated that the differences in mortality obtained were dependent on the actual amount of malathion discharged regardless of the addition of resmethrin.

This research was prompted by several unpublished reports of increased kill of both susceptible and resistant mosquito species with various formulations of malathion and resmethrin as compared to malathion when applied as ULV ground aerosols. Although most reports were rather poorly documented and included little or no data comparing the degree of kill obtained with or without resmethrin, they did indicate a good kill of adult mosquitoes with malathion-resmethrin formulations.

To evaluate the effectiveness of malathion-resmethrin formulations, the following controlled laboratory and field tests were conducted in 1979 and 1980 comparing various formulations of malathion and resmethrin to malathion only.

METHODS

Laboratory testing procedures consisted of exposing laboratory reared adult mosquitoes in 6 inch diam. screen cages, each containing ca 25 female mosquitoes, to 0.5 ml of an acetone solution of the toxicant in a laboratory wind tunnel. Each test consisted of exposing duplicate cages to each of 5 dosages plus a check of acetone only and 4 to 5 tests were conducted with each toxicant. The LC_{50} and LC_{90} dosages, confidence limits and the slope and the standard error of the slope of the dosage-mortality regression line were obtained by probit analysis of the data.

Field tests were conducted in the early evening hours after sunset. Temperatures during the tests ranged from 75 to 85°F. and averaged 81.2°F. Wind velocity ranged from 2 to 8 mph and averaged 5.2 mph. The test plot was a fairly open beach residential area containing scattered houses, a few large pine trees and sparse ground vegetation. Four 6 inch diam cages of mosquitoes, 2 of *Culex nigripalpus* Theobald and 2 of either *Aedes taeniorhynchus* (Wiedemann) or *Cx. quinquefasciatus* Say, each containing ca 25 female mosquitoes, were attached to a metal pole. One cage of each species was hung at 6 ft. and another at 2 ft. above the ground. The poles were placed at 165 and 330 ft. downwind and perpendicular to the line of travel of the first swath of the aerosol generator. A second and third swath were applied 1 and 2 blocks (300 and 600 ft.) upwind of the first swath. Each test or replicate consisted of caged mosquitoes from 3 sets of poles (165 and 330 ft.) placed a block (600 ft.) apart, or a total of 12 cages of each species.

All field tests were conducted with a Leco HD® ULV cold aerosol generator at 10 mph. The insecticide tank pressure of the tests using technical insecticides only was 4.0 psi, but because of the low viscosity of the formulations with heavy aromatic naphtha (HAN), the pressure used with the HAN formulations was reduced to 1.5 psi. Spraying time was recorded by a stop watch and the insecticide was measured before and after each test to determine output. Actual spray times varied from 15 to 20 min, depending on the length of run necessary to completely cover the test area. Two paired tests, one with a malathion-resmethrin formulation and one with malathion only were conducted each night in the same area and from 2 to 4 of these paired tests were conducted with each formulation. To avoid bias, the order of the paired tests was reversed each night.

The mosquitoes used in both the laboratory and field tests were from laboratory colonies and were between 2 and 8 days old at the time of testing. After exposure, the mosquitoes were transferred to clean holding cages and held with access to a 10% sugar solution on cotton pads. Posttreatment mortality counts for the laboratory and field tests were made at 24 hrs. and 12–15 hrs., respectively, except where otherwise indicated. Tests of the malathion resistant *Ae. taeniorhynchus* were conducted with F_1 adults, the parents of which were collected in various areas of the state and shipped to the laboratory. In all tests, the ratio of the malathion to resmethrin was based on the weight of active ingredients. In the formulations with HAN, the ratio of malathion to HAN or malathion to resmethrin plus HAN was 7:5 by volume. The malathion formulation used was the malathion ULV concentrate which contained 91.0% malathion. The resmethrin formulation used was the SBP-1382 40MF which contained 40.0% resmethrin.

RESULTS

The results of the laboratory tests comparing malathion-resmethrin at 90:1 and malathion are shown in Table 1. The data indicate that there was a slight difference in the LC_{50} and LC_{90} dosages of both species favoring the 90:1 malathion-resmethrin formulation. These differences, however, were significant with *Cx. nigripalpus* but not with *Ae. taeniorhynchus* at the LC_{90} level.

Shown in Table 2 are the results of the laboratory tests of malathion resistant *Ae. taeniorhynchus* comparing malathion-resmethrin at 100:1 and malathion. From these data it is apparent that there was no difference in toxicity between the

Table 1. Laboratory adulticide tests comparing malathion-resmethrin (90:1) and malathion.

Insecticide	Hours posttreatment	Lethal concentration-mg AI malathion/ml. LC_{50}	95% C.L.[1]	LC_{90}	95% C.L.[1]
		Aedes taeniorhynchus			
Malathion-resmethrin	4	0.114	0.103–0.126	0.284	0.220–0.366
Malathion	4	0.113	0.100–0.128	0.348	0.242–0.500
Malathion-resmethrin	24	0.064	0.057–0.072	0.184	0.149–0.229
Malathion	24	0.084	0.076–0.092	0.214	0.171–0.267
		Culex nigripalpus			
Malathion-resmethrin	4	0.358	0.320–0.400	1.090	0.893–1.330
Malathion	4	0.509	0.443–0.584	1.920	1.439–2.563
Malathion-resmethrin	24	0.276	0.248–0.308	0.774	0.653–0.916
Malathion	24	0.338	0.286–0.400	1.991	1.400–2.773

[1] 95% Confidence limits.

Table 2. Laboratory adulticide tests of malathion resistant *Aedes taeniorhynchus* from 4 areas of Florida comparing malathion-resmethrin (100:1) and malathion.

Area	Insecticide	Lethal concentration-mg AI malathion/ml.				LC_{90}
		LC_{90}	95% C.L.[1]	LC_{90}	95% C.L.[1]	RR[2]
Marineland	Malathion-resmethrin	0.84	0.66–1.02	3.68	2.84– 4.76	37
	Malathion	0.70	0.54–0.92	3.27	2.29– 4.68	30
Flagler Beach	Malathion-resmethrin	1.23	1.00–1.51	4.19	3.11– 5.64	42
	Malathion	1.74	1.44–2.09	4.33	3.20– 5.87	39
Ruskin	Malathion-resmethrin	0.63	0.42–0.95	5.54	2.43–12.60	55
	Malathion	0.46	0.27–0.80	6.08	0.98–37.82	55
Picnic Island	Malathion-resmethrin	2.04	1.78–2.33	8.62	6.83–10.90	86
	Malathion	2.86	2.48–3.31	9.64	7.69–12.08	88
Lab colony	Malathion-resmethrin	0.053	0.48–0.59	0.10	0.09– 0.11	—
	Malathion	0.069	0.65–0.73	0.11	0.10– 0.12	—

[1] 95% confidence limits.

[2] Resistance ratio – $\frac{LC_{90}\text{ of resistant strain}}{LC_{90}\text{ of susceptible lab strain}}$

malathion-resmethrin formulations and malathion with any of the resistant populations.

The results of the field tests of ULV sprays applied by ground equipment comparing various formulations of malathion-resmethrin and malathion are shown in Table 3. The percent mortalities for the 3 species indicate that there was no difference between any of the malathion-resmethrin formulations and malathion at any of the discharge rates. It is worthy of note, however, that the kill obtained with *Cx. nigripalpus* was proportional to the actual amount of malathion discharged regardless of the formulation or the content of resmethrin. The percent mortality was evidently too high for this effect to be apparent with *Cx. quinquefasciatus*.

Table 3. Mortality of caged adult *Culex nigripalpus, Cx. quinquefasciatus* and *Aedes taeniorhynchus* exposed to various formulations of malathion and malathion-resmethrin applied as ULV aerosols by ground equipment.

Formulations		Ratio mala:res	Discharge in fl.oz./min.[3]		Average percent mortality[4]		
Insecticides[1]	ratio v/v[2]	wt/wt AI	total	mala	*Cx. nig.*	*Cx. quinq.*	*Ae. taen.*
Malathion-HAN	7:5	—	4.3	2.5	96	100	—
Mala-res-HAN	7:5	100:1	4.3	2.5	95	100	—
Malathion	—	—	2.1	2.1	89	96	—
Malathion-resmethrin	—	100:1	2.1	2.1	86	97	—
Malathion-HAN	7:5	—	3.2	1.9	77	100	—
Mala-res-HAN	7:5	100:1	3.2	1.9	81	99	—
Malathion	—	—	1.4	1.4	74	—	99
Malathion-resmethrin	—	89:1	1.4	1.4	78	—	98

[1] Mala = malathion, res = resmethrin, HAN = heavy aromatic naphtha.

[2] Ratio of malathion to HAN or malathion to resmethrin plus HAN (v/v).

[3] Total = discharge of total formulation; mala = discharge of malathion portion of formulation only.

[4] Average of 2–4 tests, *Cx. nig.* = *Culex nigripalpus*, *Cx. quinq.* = *Cx. quinquefasciatus*, *Ae. taen.* = *Aedes taeniorhynchus*.

DISCUSSION

This research was prompted by reports of increased kill of both susceptible and resistant mosquito species with the addition of small amounts of resmethrin to malathion and was initiated to test this hypothesis. The results obtained indicate a small but detectable increase in toxicity of malathion-resmethrin formulations in the laboratory against *Cx. nigripalpus*, but no difference between formulations of malathion-resmethrin and malathion only could be demonstrated in the laboratory against malathion susceptible or resistant *Ae. taeniorhynchus* or in the field against *Cx. nigripalpus*, *Cx. quinquefasciatus* or *Ae. taeniorhynchus*. In retrospect, however, there appear to be sound reasons for its failure. The lack of effectiveness of resmethrin against *Ae. taeniorhynchus*, shown in previous testing (Boike and Rathburn 1975; Rathburn and Boike 1972b, 1972c, 1975, 1976; Rathburn et al. 1978), indicate that the addition of very small amounts of resmethrin to malathion would be of no value. Although resmethrin has been shown to be very effective against *Culex* spp., the addition of the very small amounts of resmethrin to malathion would also be of little value, since malathion has been shown to be considerably less effective against *Cx. nigripalpus* than against *Ae. taeniorhynchus* (Boike and Rathburn 1975; Rathburn and Boike 1972a, 1972b, 1972c, 1975, 1977; Rathburn et al. 1964, 1965). Although mosquito species other than those tested here may react differently to the mixture, and different mixtures may possibly show some increase in effectiveness, the increased cost of the mixtures would necessitate obtaining satisfactory control of the target species with a substantial reduction in discharge rates to be economically beneficial.

References Cited

Boike, A. H., Jr. and C. B. Rathburn, Jr. 1975. Laboratory non-thermal aerosol tests of insecticides for the control of adult mosquitoes. Mosq. News 35:488–490.

Rathburn, C. B., Jr. and A. H. Boike, Jr. 1972a. Ultra low volume tests of malathion applied by ground equipment for the control of adult mosquitoes. Mosq. News 32:185–187.

Rathburn, C. B., Jr. and A. H. Boike, Jr. 1972b. Laboratory thermal aerosol tests of new insecticides for the control of adult mosquitoes. Mosq. News 32:197–183.

Rathburn, C. B., Jr. and A. H. Boike, Jr. 1972c. Ultra low volume tests of SBP-1382 applied by ground equipment for the control of adult mosquitoes. Mosq. News 32:334–337.

Rathburn, C. B., Jr. and A. H. Boike, Jr. 1975. Ultra low volume tests of several insecticides applied by ground equipment for the control of adult mosquitoes. Mosq. News 35:26–29.

Rathburn, C. B., Jr. and A. H. Boike, Jr. 1976. Tests of resmethrin with several synergists in a laboratory wind tunnel against caged adult mosquitoes. Mosq. News 36:204–205.

Rathburn, C. B. Jr. and A. H. Boike, Jr. 1977. Bioassay and droplet size determinations of six ULV aerosol generators. Mosq. News 37:31–34.

Rathburn, C. B., Jr., A. H. Boike, Jr., C. F. Hallmon and S. G. Cotterman. 1978. Laboratory tests of the effectiveness of selected adulticides and larvicides against a wild strain of *Aedes aegypti* (Linnaeus) as compared to a laboratory strain of *Aedes taeniorhynchus* (Wiedemann) 1978. Proc. Fla. Anti-Mosq. Assoc. 49:1–3.

Rathburn, C. B., Jr., B. W. Clements, Jr. and A. J. Rogers. 1964. Comparative thermal aerosol tests of Dibrom and malathion against *Aedes taeniorhynchus* (Wied.) and *Culex nigripalpus* Theob. Mosq. News 24:292–294.

Rathburn, C. B., Jr., B. W. Clements, Jr. and A. J. Rogers. 1965. Comparative tests of fog oils and diesel oil as thermal aerosols for control of adult mosquitoes. Mosq. News 25:101–106.